



# “The Space Shuttle Columbia Preservation Project – The Debris Loan Process”

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## Columbia Preservation Project

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- Purpose:
  - Provide a process for loan of Columbia debris to qualified researchers and technical educators
- Aid in advanced spacecraft design and flight safety development
- Advance the study of hypersonic re-entry to enhance ground safety.
- Train and instruct accident investigators
- Establish an enduring legacy for Space Shuttle Columbia and her crew.





## Columbia Recovery Office

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- The Columbia Recovery Office was formed at JSC at the conclusion of recovery operations on May 1<sup>st</sup>
- In October the SFOC contract was changed to incorporate the Columbia Recovery Office and Preservation, subsequently the CRO was transferred to USA/KSC on October 6<sup>th</sup>
- Using (866) 446-6603, this is the same phone number used throughout the recovery, anyone can call about debris
  - Phone rings in OSB 6<sup>th</sup> floor, USA GO Program Office
  - Information is taken and input into Shuttle Interagency Debris Database (SIDDs). Name, contact #s, location
  - Any available pictures or information is forwarded to PH/GO for determination of Orbiter hardware or not
  - If designated hardware and within 25 miles of the current known debris path Weston (EPA contractor that participated in recovery) will recovery and transport to NASA Palestine Balloon facility. Subsequently items are shipped to KSC
  - Otherwise the person is directed to transport item to local authority and contact NASA where we give Fed Ex shipping number and send to KSC
  - Once at KSC item is inventoried into Reconstruction/Preservation database and placed on 16<sup>th</sup> floor of VAB

# Debris Check-in Process

## Receiving Materials (CRO/Weston)

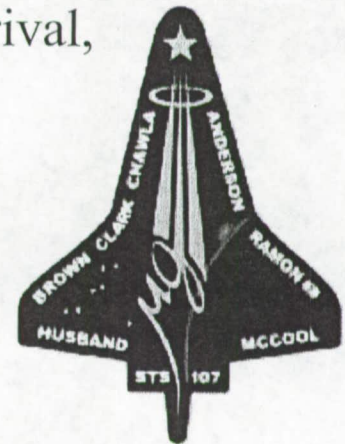
- Toxic Vapor Checks are performed on all items before processing

## Quality Receiving

- Debris items are:
  - ✦ Photographed bar-coded and tagged
  - ✦ Entered into CRDS. Multiple items are separated into parent/child relationships
  - ✦ Data records include item description, time and date of arrival, longitude/latitude and date and time of recovered area.

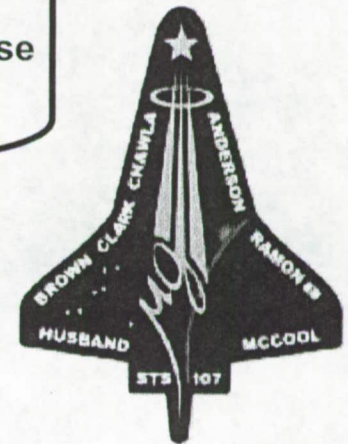
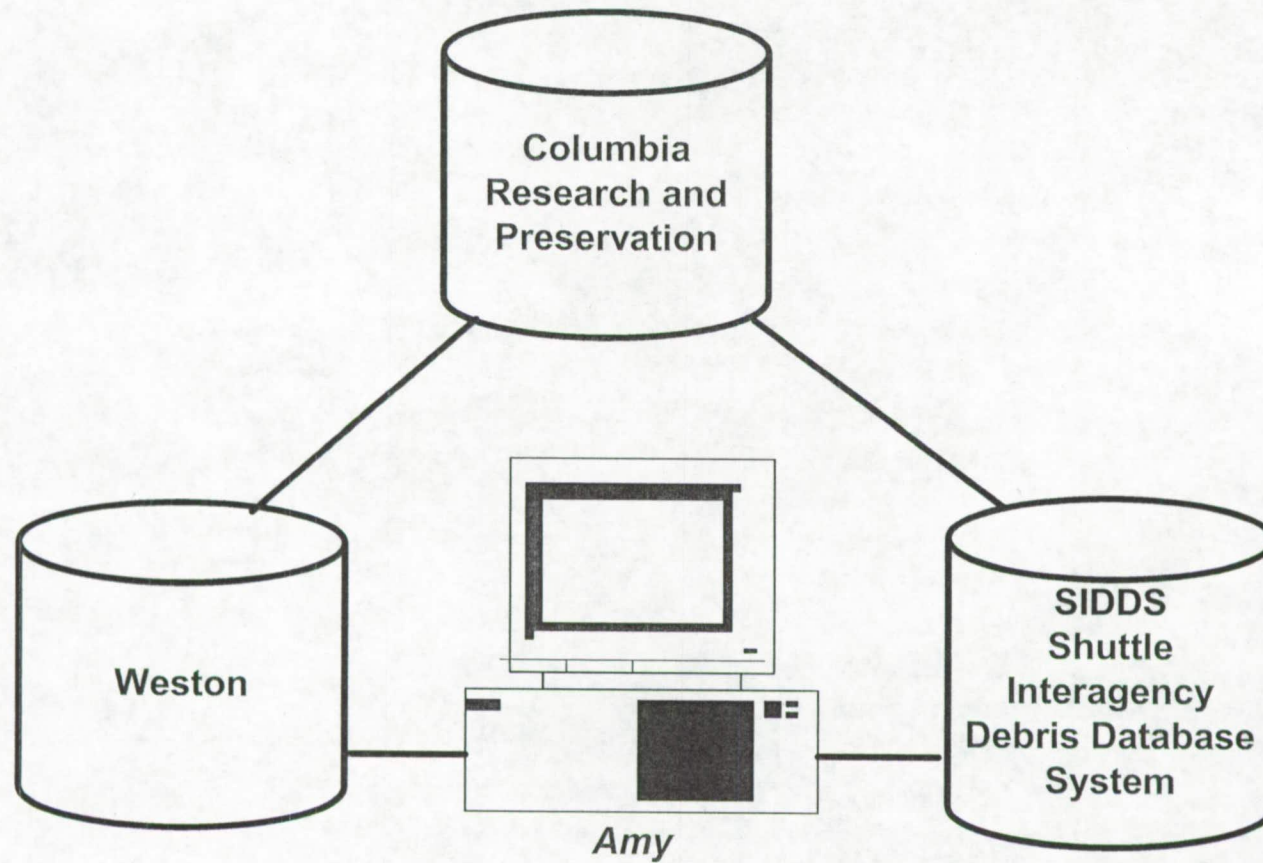
## Movement of Debris

- Handler assign items to locations for storage according to size, weight, and system identification





# Database Interface



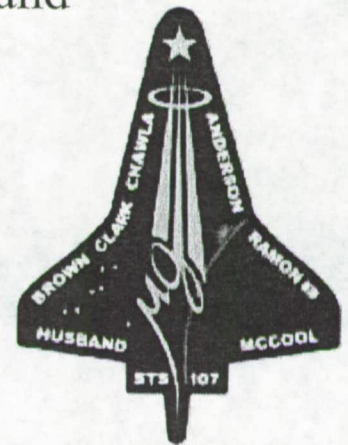
# Coordination of Debris Requests

## Internal to Space Shuttle Program

- Requestor fill out Debris Loan Request and contacts Columbia Research and Preservation Office for validation and approval.
- Forward to following for release approval
  - ✚ Space Shuttle Orbiter Project Office (OPO) Manager (JSC/MV)
  - ✚ Flight Crew Operations Directorate (FCOD)/ Astronaut Office if crew module debris is involved.
  - ✚ Space Shuttle Deputy Program Manager at KSC (MK)
  - ✚ Columbia Research and Preservation Office for database entry and coordination for shipping

## Shipping of Material

- Coordinated with USA logistics.
  - ✚ Generate DD1149
  - ✚ Tracking number entered into CRDS



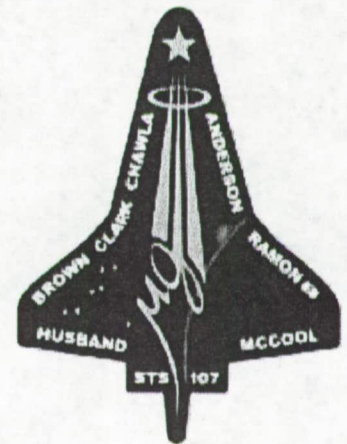


# Coordination of Debris Requests

## External to Space Shuttle Program

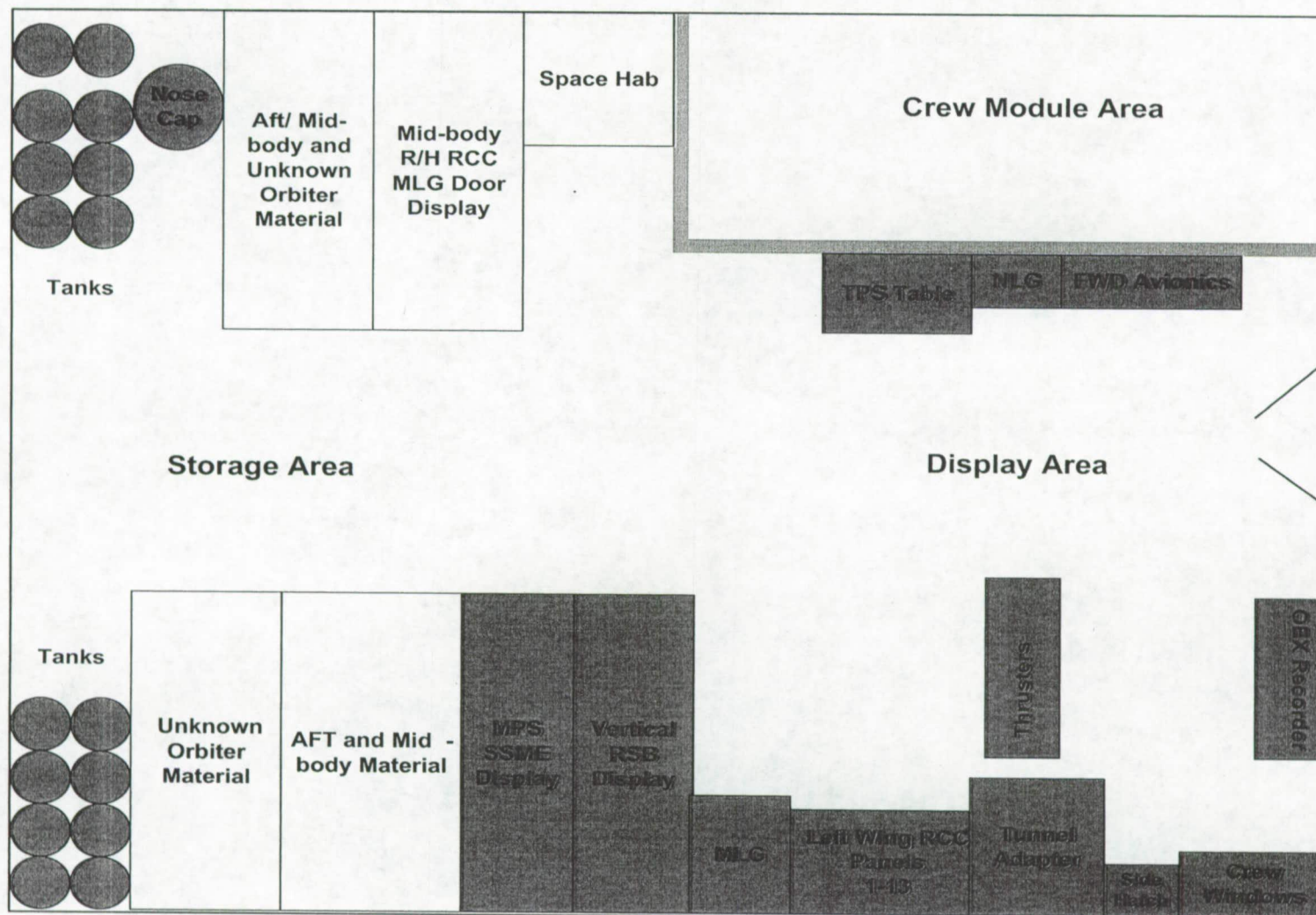
➤ The NASA Review and Approval Committee will consist of the following individuals for concurrence:

- ✦ Designated NASA Approval Authority ( Space Shuttle Program Manager)
- ✦ Technical Expert ( Subsystem Manager)
- ✦ NASA expert in research process.
- ✦ NASA Legal
- ✦ NASA Education ( education-related request)
- ✦ FCOD/Astronaut Office





# Columbia Preservation Project

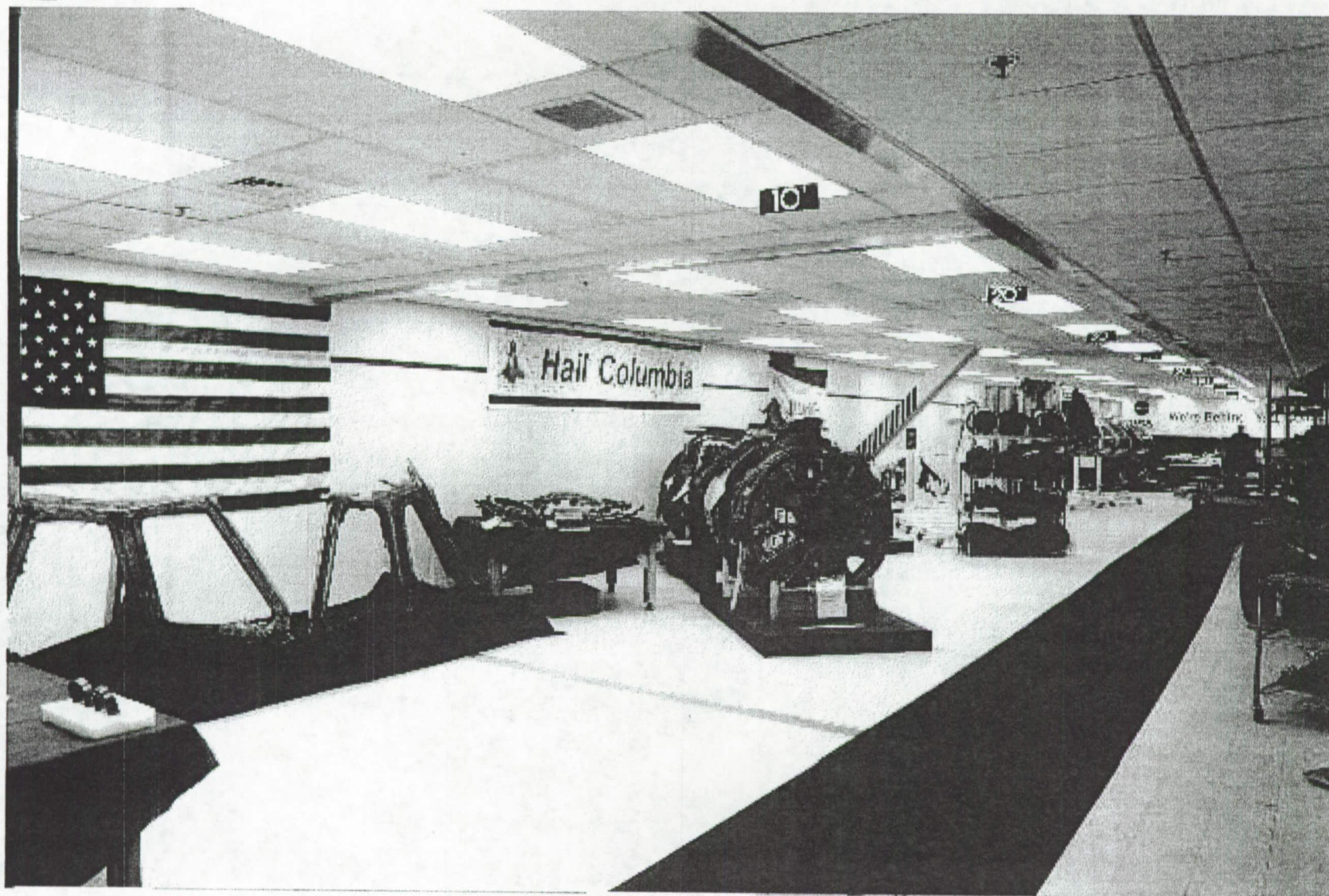






## Columbia Preservation Project

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## Columbia Preservation Project

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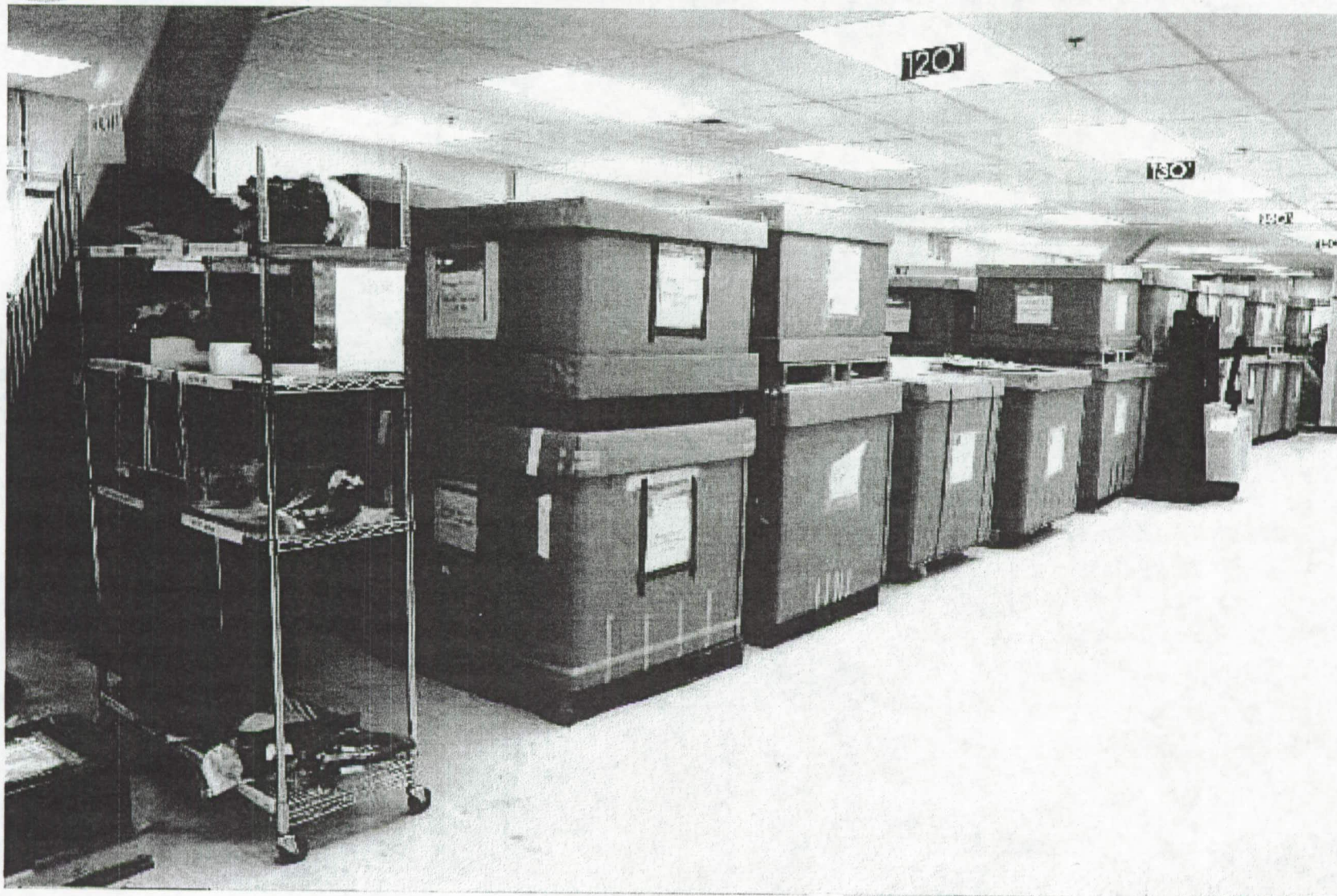






## Columbia Preservation Project

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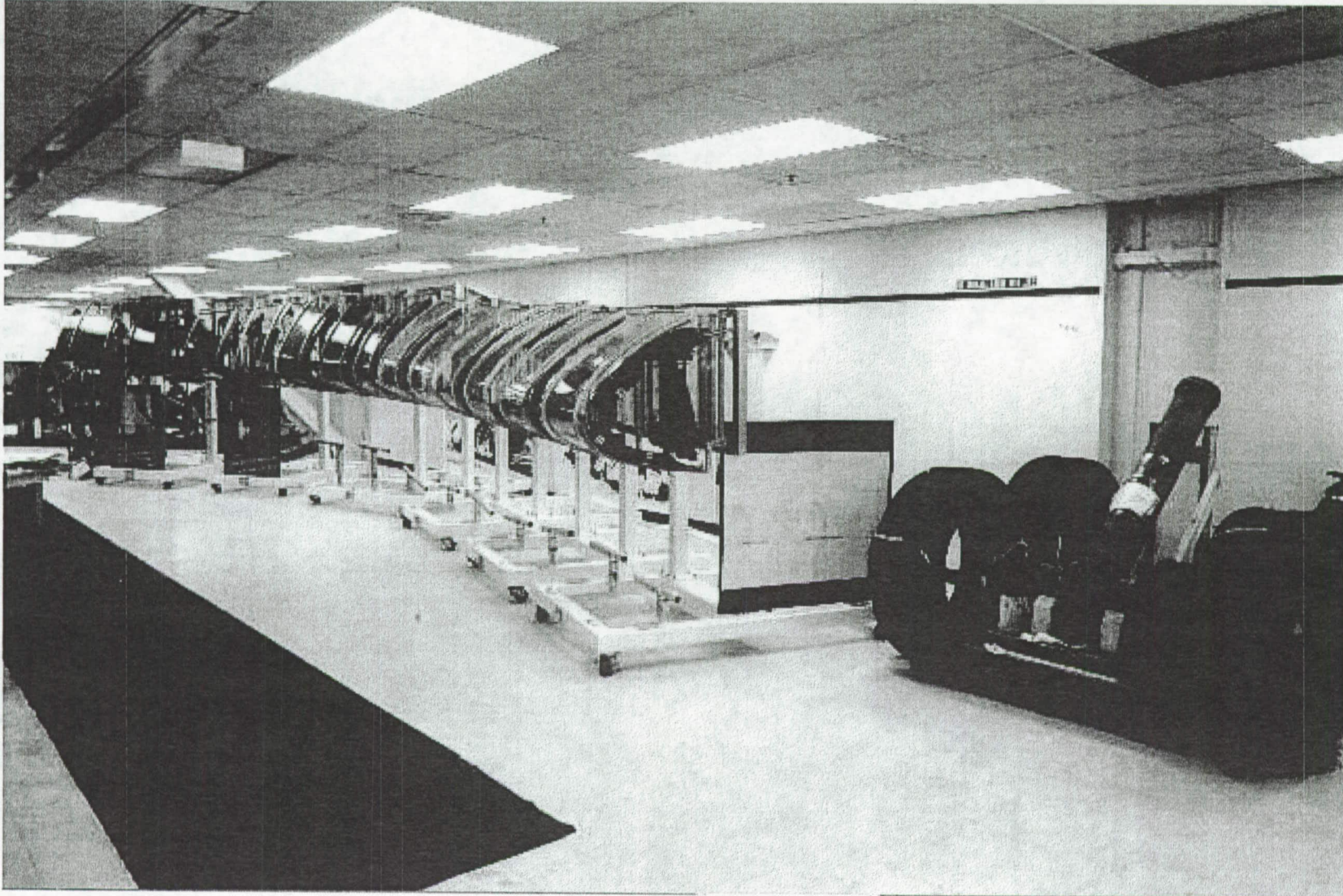






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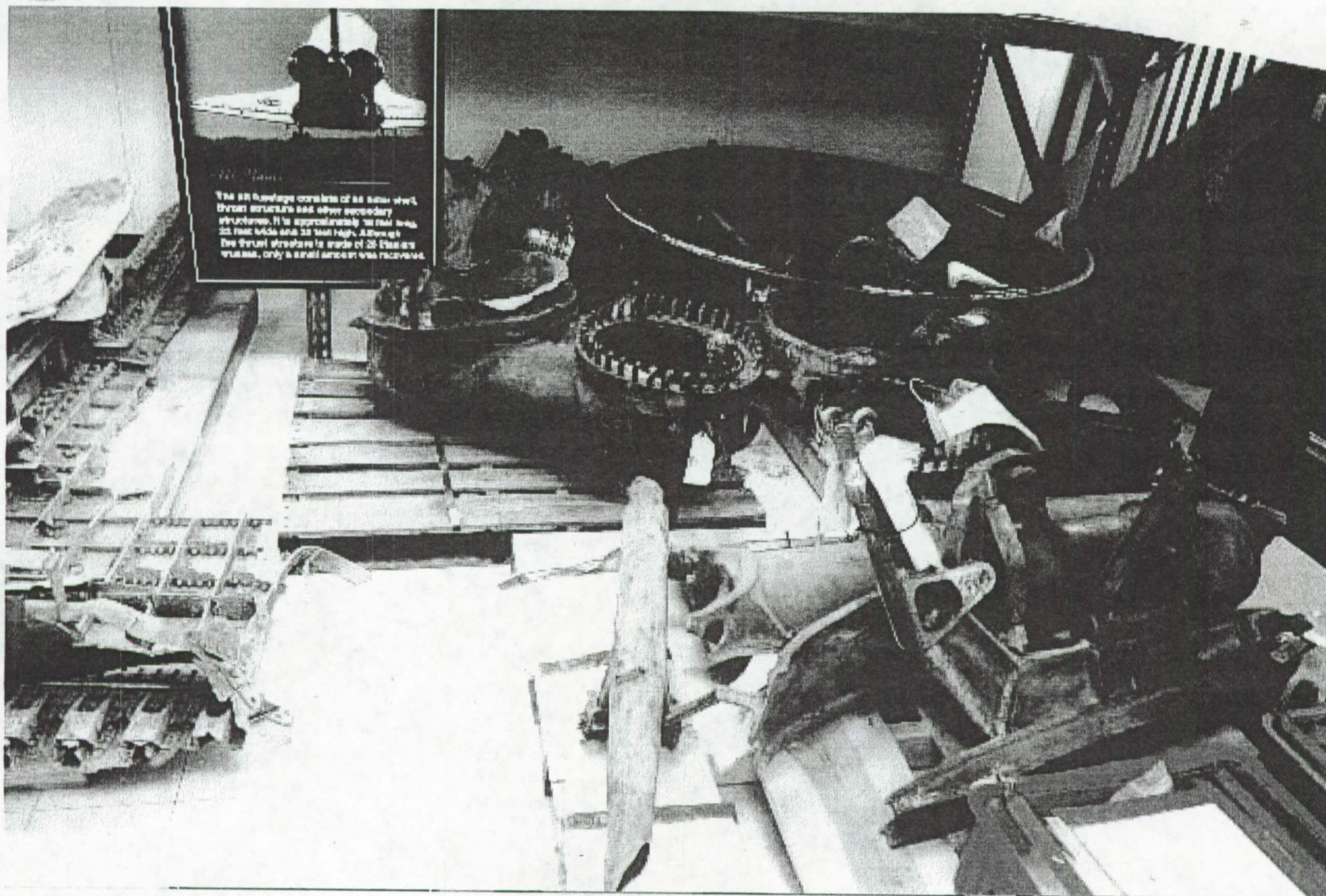






## Columbia Preservation Project

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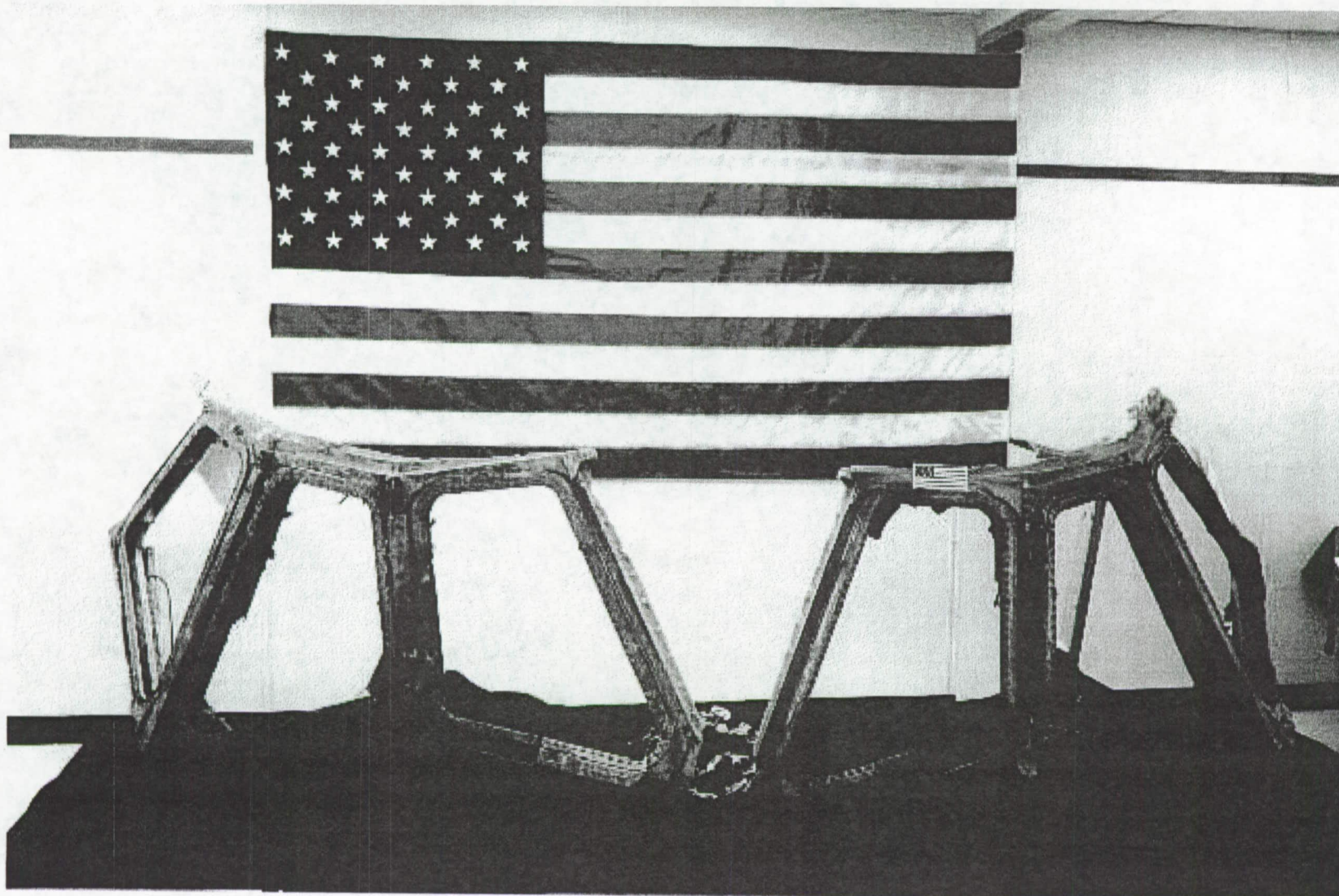






## Columbia Preservation Project

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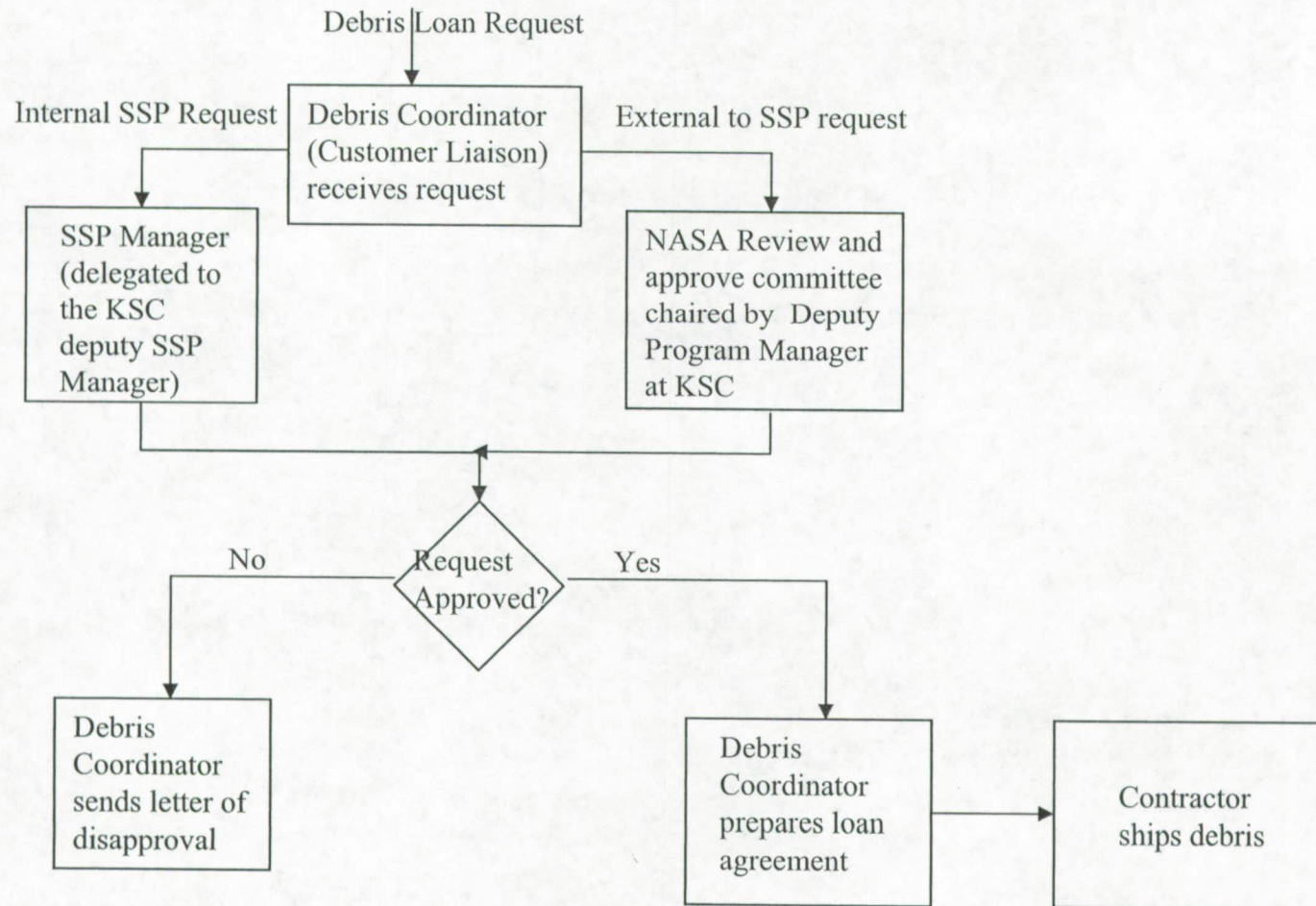






# Columbia Preservation Project

## Columbia Debris Loan Process







LEHIGH  
UNIVERSITY



*The Columbia Debris Failure Analysis  
Program at  
Lehigh University*

*R. M. Deacon  
A. R. Marder*

*AeroMat 2005*



# Mat 338 – Failure Analysis Reports

- Capstone senior level materials science and engineering course
- Requires students to draw on knowledge learned in previous 3½ years
- Discuss mechanisms and identification of various failure modes in lectures
- Hands on demonstrations of actual failures in laboratory session
- Culminates in independent failure analysis project



# Why Study Columbia Debris?

- *Excellent example of real life failure*
  - Complex materials experienced severe loads and temperatures during hypersonic re-entry
  - Unknown sample history / background
  - Little data on loads and conditions at failure
  - Sample contamination issues
- *Opportunity to turn tragic event into an educational learning tool*

# The Process

1. Assignment of debris
2. Observations and planning
3. Submission of cut plans
4. Sectioning and metallography
5. Light optical microscopy
6. Scanning electron microscopy / EDS

Emphasized throughout –

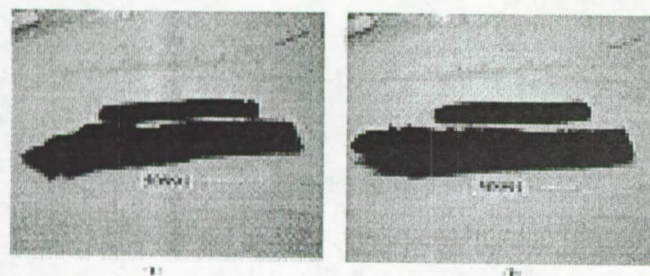
**DOCUMENTATION and SECURITY**



## Sample Cut Plan

† *Paraburys* *Paraburys* sp. n.

Delmar #9991 is a monogenic piece of the Columbia series. Figure 1 shows photomicrographs of the top surface of the delma. Fig. 1a and of the bottom surface of the delma. Fig. 1b.



2. *Staphylococcus aureus* (Staph. aureus) is a common cause of skin infections, such as abscesses, boils, and impetigo. It is also a leading cause of hospital-acquired infections, including pneumonia, bloodstream infections, and surgical site infections.

## References

Four different sections are to be compared from station to station for the same analysis. Figure 1 shows the 14 parameters that are to be made at the entire series of stations. Sections 1 and 2 have a vertical line through them and a line at the end of each of them indicating the uppermost, lowermost, and the mean horizontal layers of the strata in the analysis. A

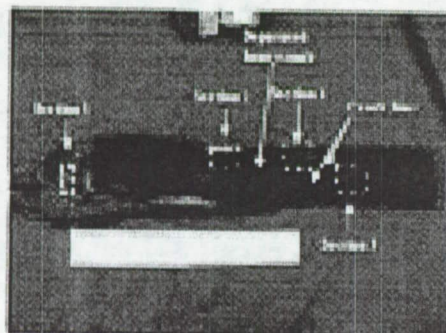


Figura 1. Ejemplo de un caso de losa +0000.1. El caso de losa +0000.1 se refiere a la losa +0000.1 de la planta de losa +0000.1 de la planta de losa +0000.1.

management, analysis of the various marketing functions, their present and future trends, and understanding of the types of financial resources. The analysis will be performed using a group and an individual method. The individual method involves students working separately, based on the company's financial data, and development of a written report of the final solution to the case. The analysis that is presented to a large group of registered students, and discussion of them, is shown in Figure 1. Results are analyzed from the group point of view. A written final solution to the case is developed, analysis of the group work helps to determine the degree of success of finding and, perhaps, the cause of failure for the management of the company. Generalized information received by the students, and the degree of materialization of the plan, will be an indicator of the company for evaluation of the final results and a measure of the level of the study conducted.

It should be noted that, in addition, a group and individual analysis of the region will allow for a more detailed analysis of the financial and economic situation of the region.

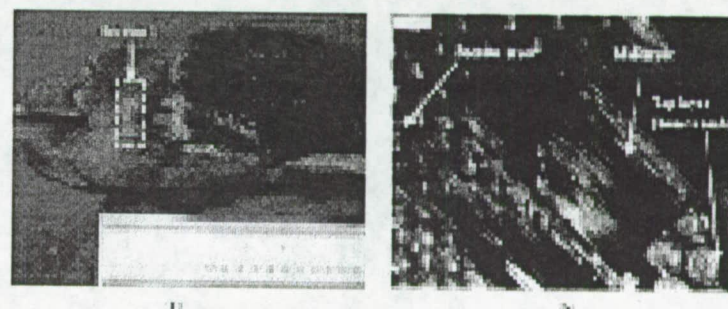
[illegible]

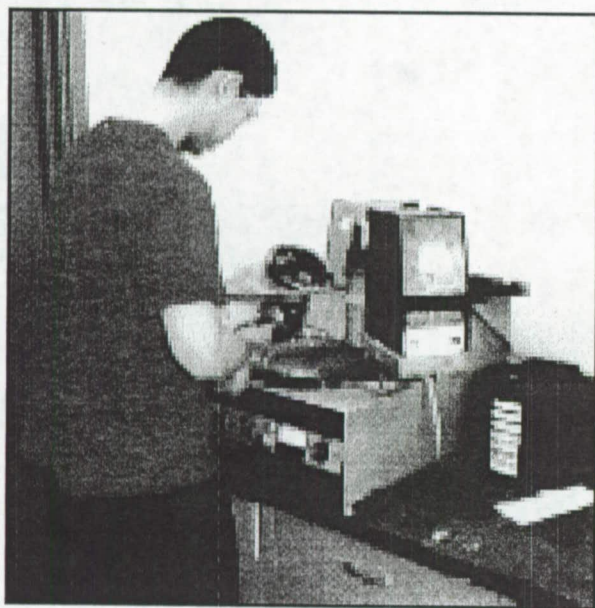
Figure 2. The mean  $\pm$  SD of the total alkaline phosphatase (ALP) activity (U/L) of the patients with the diagnosis of the disease. The mean  $\pm$  SD of the ALP activity of the patients with the diagnosis of the disease was significantly higher than that of the healthy controls ( $p < 0.05$ ).

A principled, imaginative and selfless adherence to the defense must be a key to "surviving" whether through the criminal justice system, state or federal, or through the military justice system. The defense team of a prosecutor will be

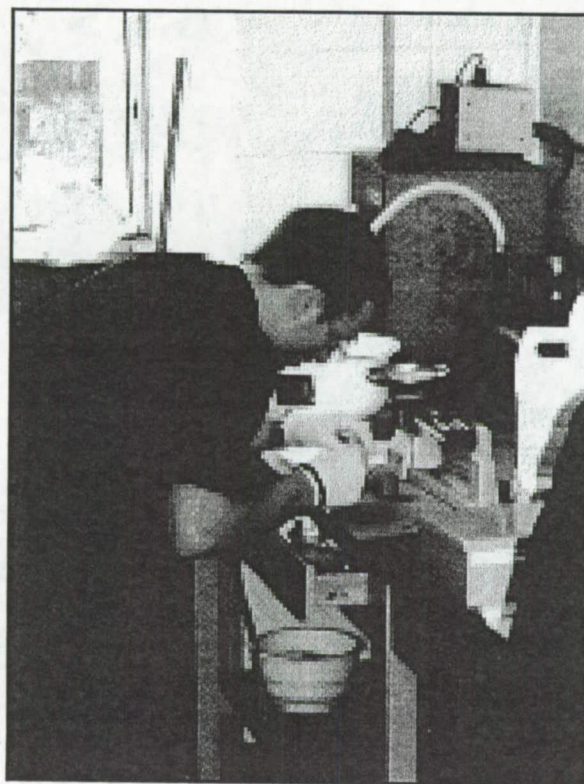


# Sample Preparation

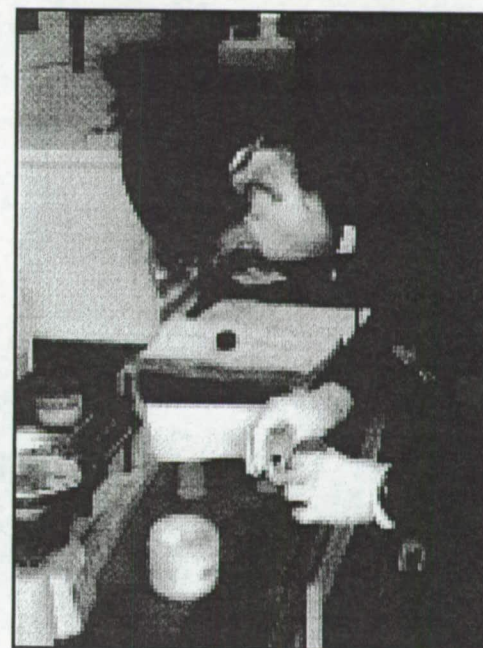
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*Polishing Aluminum  
Samples*



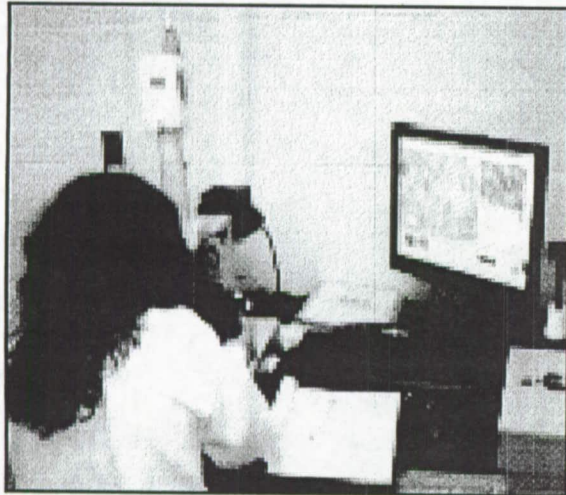
*Epoxy  
Impregnation*



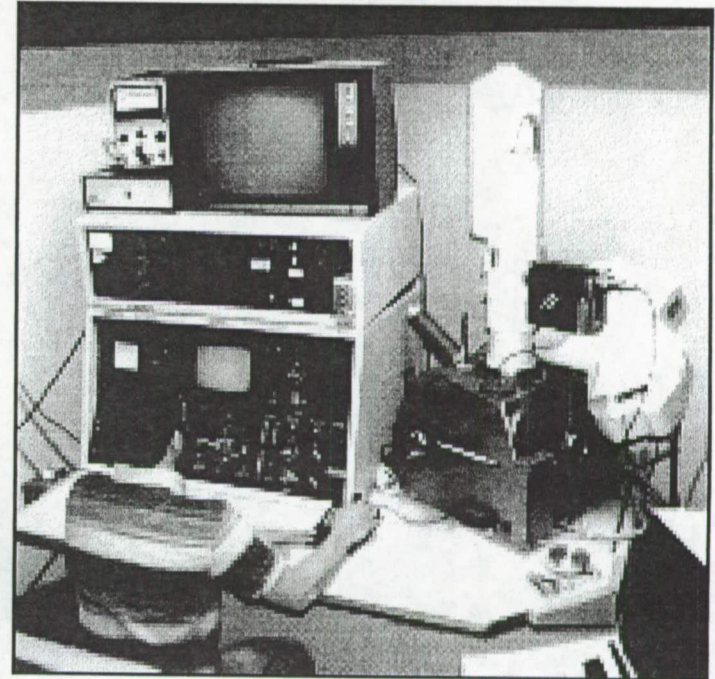
*Mounting Tile  
Sections*



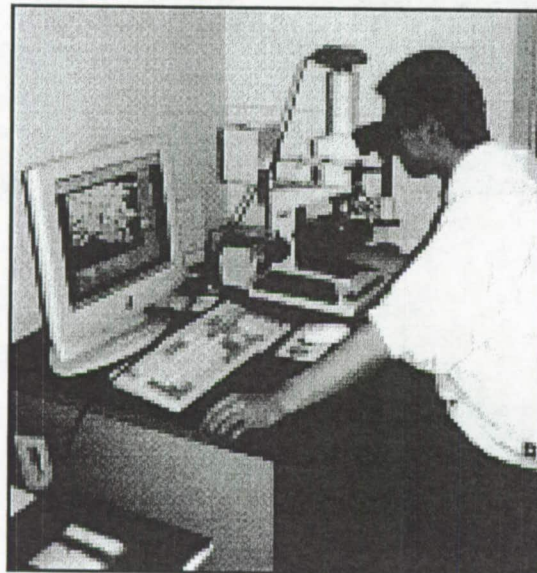
# Image Analysis, LOM, SEM



*Digital Image  
Analysis*



*Dedicated  
Undergraduate  
Scanning Electron  
Microscope*



*Digital Image  
Archiving  
System*



# Media Coverage

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- *Associated Press*
- *Fox Philadelphia*
- *CBS Harrisburg*
- *Lehigh Valley Tempo*
- *The Morning Call*



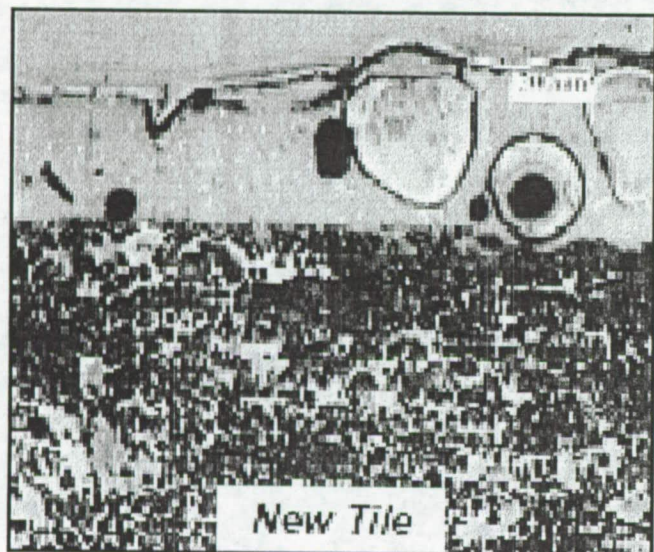
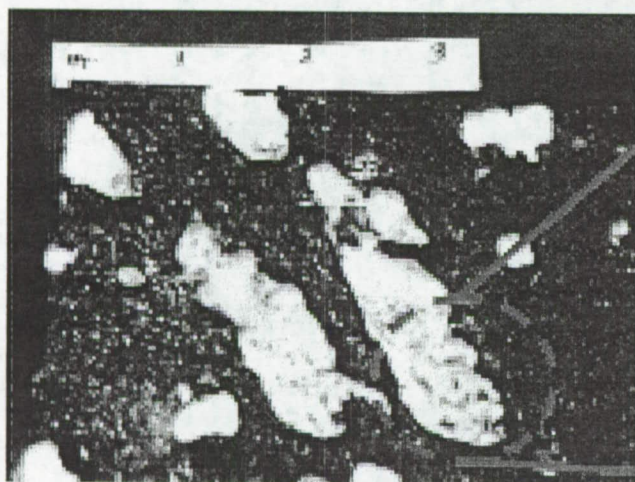
*Professional  
development experience*



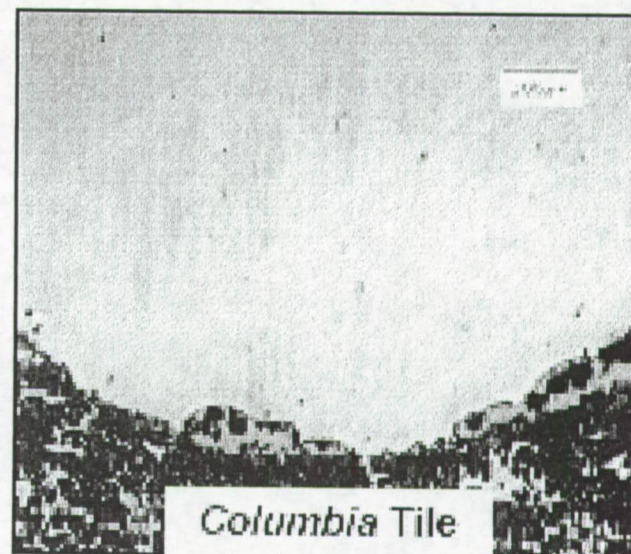
# Analysis of Columbia Tile:

## Slumping of RCG Layer

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*Comparison of  
RCG Layer on  
New and  
Recovered  
Columbia  
Tiles*

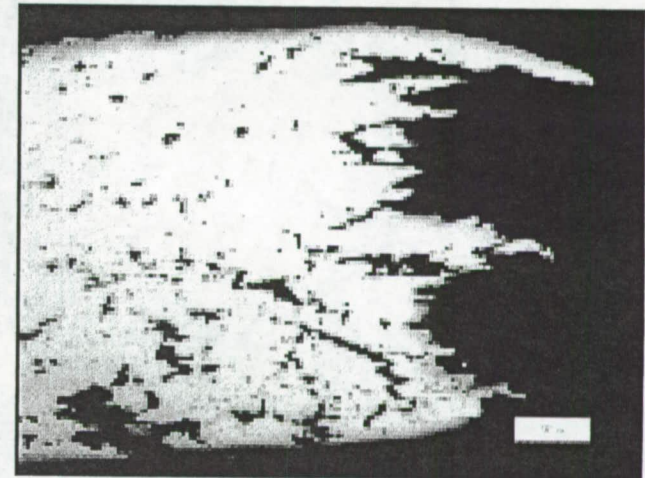
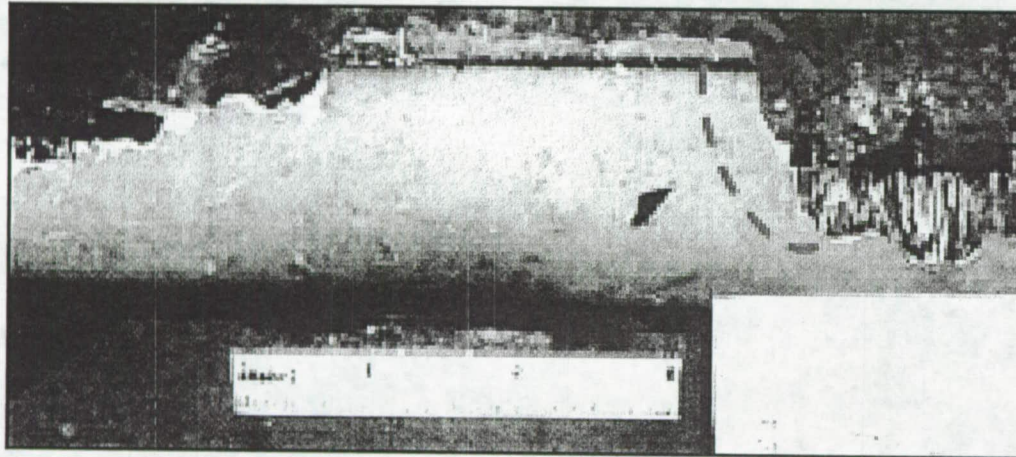




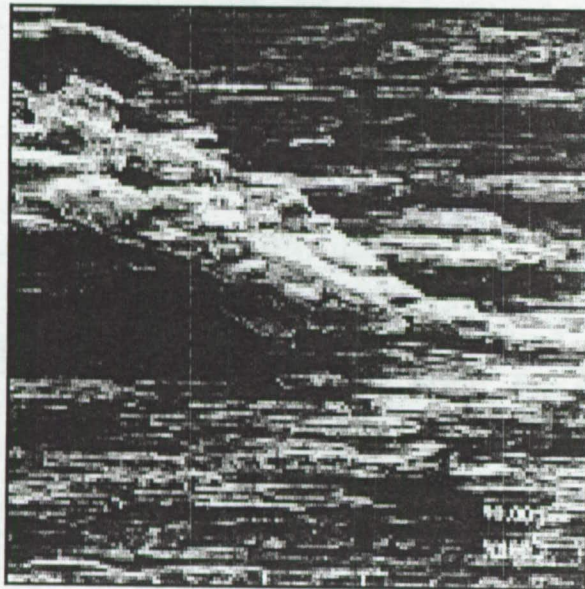
# Analysis of A1 Upper Spar Fitting:

## Void Formation and Intergranular Fracture

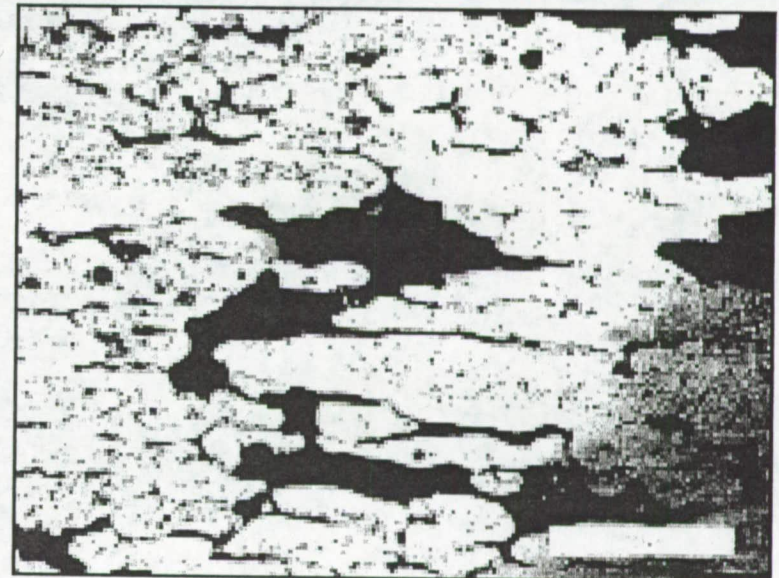
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*Void  
Formation*



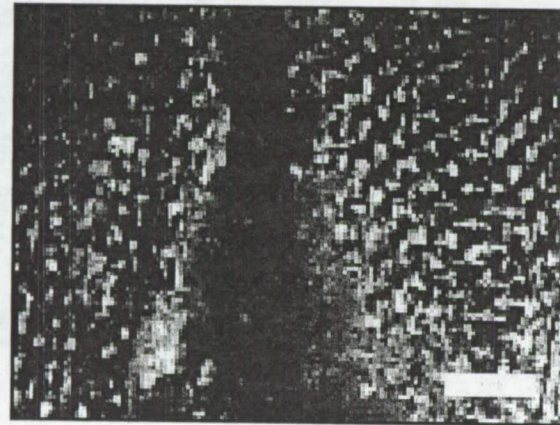
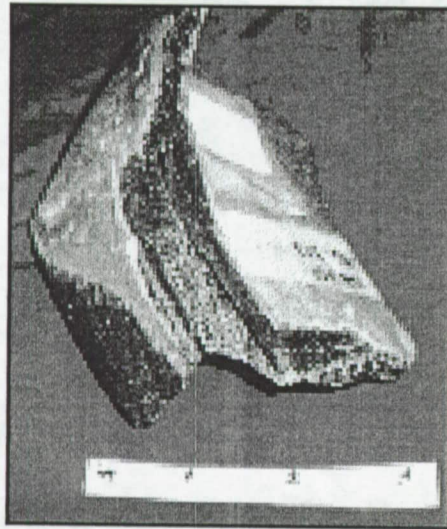
*Intergranular  
Fracture*



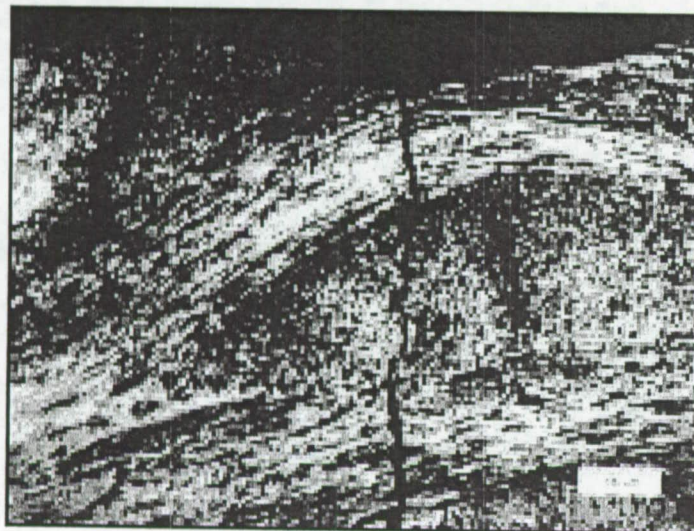


# Analysis of RCC T-Seal:

## SiC Erosion and Cracking

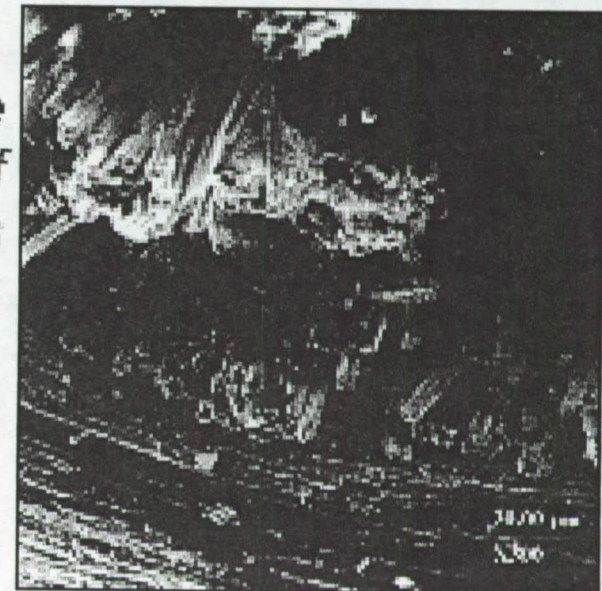


*Erosion  
of SiC  
Layer*



*Cracks  
through  
SiC layers*

*Brittle  
fracture of  
fibers*





# Conclusions

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- Excellent project for failure analysis class
- Students experience
  - Real life failure analysis
  - Working in secure environment
  - Interactions with the media
- Student analysis of debris adds to NASA knowledge base
- Program should be continued in the future